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BRUCE HEAVY WATER PLANT
THIRD STAGE H_2S BLOWER MOTORS
VIBRATION ANALYSIS

Report No 87-152-K

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N.A. Jagan - Engineer
Plant Equipment Dynamics Section
Mechanical Research Department

ABSTRACT

A vibration analysis was carried out on two Third Stage H_2S Blower Motors to determine the causes of the high vibration levels. The investigation revealed that defective rotor/stator components and excessive rotor eccentricity as well as amplified rotor response due to a rotor critical speed near the operating speed are the probable causes of high vibration. It is recommended that the motors be inspected for defective components and modifications be implemented to shift the rotor critical speed sufficiently away from the operating speed.

job	file	date	report no.
27-183-552	825.4	August 19, 1987	87-152-K

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EXECUTIVE SUMMARY

BRUCE HEAVY WATER PLANT
THIRD STAGE H_2S BLOWER MOTORS
VIBRATION ANALYSIS

Report No 87-152-K

F. Perricone and N.A. Jagan
Plant Equipment Dynamics Section
Mechanical Research Department

The Third Stage H_2S Blower Motors have a long history of high vibration levels which have resulted in motor failures. Mechanical Research was requested to investigate and identify the cause(s) of the high vibration levels measured on two motors and to make recommendations.

The results of the investigation indicate that the motor vibrations are high and corrective actions should be taken. The main frequency components are at 1 and 2 x rpm $\pm$ slip side bands and 120 Hz. Defective rotor/stator components and excessive rotor eccentricity as well as amplified rotor response due to a rotor critical speed near the operating speed are the probable causes of high vibration.

It is recommended that the motors be inspected and defective components be replaced. In addition, modifications such as motor bearing stiffening, bearing redesign and the implementation of dynamic vibration absorbers should be considered to detune the rotor critical speed.

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To Mr. G. Harris
Bruce Heavy Water Plant

BRUCE HEAVY WATER PLANT
THIRD STAGE H_2S BLOWER MOTORS
VIBRATION ANALYSIS

1.0 INTRODUCTION

The Third Stage H_2S Blower Motors have a long history of high vibration levels which have resulted in motor failures. Recent vibration measurements taken on the motors by BHWP Maintenance Personnel indicate that some motors are operating with high vibration levels. The motors are Canadian General Electric 2 pole induction motors equipped with journal bearings and rated at 1306 kW at 3567 rpm.

Research was requested to carry out an investigation. The main objectives were to:

1. Measure and determine the severity of the overall vibration levels for two motors.

2. Identify the most probable cause(s) for the high vibrations.

3. Provide recommendations for corrective actions.

2.0 TEST METHOD, INSTRUMENTATION AND MEASUREMENTS

2.1 Test Method

Vibration measurements were taken on the inboard and outboard bearing casings of two Third Stage H_2S Blower Motors - 'B' Plant E3 and E4 Blower Motors, while the motors were operating under load. The general motor arrangement, measurement locations and directions are shown in Figure 1.

2.2 Instrumentation

The instrumentation setup is shown in Figure 2 and also discussed in Section 2.3.

2.3 Measurements

2.3.1 Overall Velocity Levels

The overall velocity levels were determined from accelerometer (Bruel & Kjaer Model 4368) signals which were integrated and analyzed with a Bently Nevada Digital Vector Filter (DVF2).

2.3.2 Velocity Spectra

Velocity spectra were generated by analyzing the accelerometer signals (integrated once) with an Ono Sokki CF920 dual channel FFT analyzer. Hard copies of the spectra were obtained with a digital plotter (Hewlett-Packard 7470A).

Each velocity spectrum shown in this report is the result of sixteen averages.

3.0 RESULTS

3.1 Overall Velocity Levels

The overall velocity levels at the six measurement locations (and the corresponding velocity spectra Figure numbers) for the E3 and E4 motors are summarized in Tables 1 and 2, respectively. The maximum overall velocity levels measured on the two motors are 5.4 mm/s for the E3 motor (inboard bearing casing axial direction), and 9.7 mm/s for the E4 motor (inboard bearing casing axial direction). These maximum overall velocities plotted on a general machinery severity chart (Figure 15), show that the E3 motor is operating in the slightly rough to rough condition, and the E4 motor in the rough to very rough condition. These vibration levels are considered high for this type of rotating equipment. Therefore, corrective action is recommended.

Velocity spectra obtained on the E3 motor bearing casings (Figures 3-8, 20) and on the E4 motor bearing casings (Figures 9-14, 22) show that the main frequency components are at 1 x rpm (~59.5), 2 x rpm (~119 Hz) , and 120 Hz.

3.2 Motor Electro-Magnetic Vibration

3.2.1 Beating

Time graphs obtained on the E3 motor inboard bearing casing (axial and vertical directions) and on the E4 motor inboard bearing casing (axial direction) show significant "beating" in the vibration signal (Figures 16-18). The signals have a modulation period of approximately 1.488 seconds (E3

motor) and 1.231 seconds (E4 motor) which is equal to the 2 x slip period of the particular motor. The slip period is defined as follows:

$$T_{slip} = 1/F_{slip}$$

and

$$F_{slip} = F_{line} - F_{running\ speed}$$

where

T_{slip} = Slip Period (s)
F_{slip} = Slip Frequency (Hz)
F_{line} = Line Frequency (Hz)
$F_{running\ speed}$ = Running Speed Frequency (Hz)

This significant beating in the signals indicates that there is a motor electro-magnetic problem related to improperly installed or defective rotor and/or stator components.

3.2.2 2 x Slip Frequency Modulations

Zoom velocity spectra obtained on the E3 motor inboard bearing casing (axial direction) show sideband frequencies at the 1 x rpm (59.6719 Hz) and the 2 x rpm (119.3359 Hz) frequencies spaced at about 0.6719 Hz (Figures 19 and 20). These spacing intervals are equal to the 2 x slip frequency of the E3 motor. Similar zoom velocity spectra obtained on the E4 motor inboard bearing casing (axial direction) also show the 1 x rpm (59.5937 Hz) and 2 x rpm (119.1875 Hz) frequencies with 2 x slip (0.8125 Hz) frequency sidebands (Figures 21 and 22). The appearance of the sidebands around 1 x and 2 x running speed is due to modulation of the 1 x rpm and 2 x rpm frequencies by the 2 x slip frequency.

Frequency components at 1 x rpm and 2 x rpm, both with 2 x slip frequency sidebands are indicative of defective rotor components and/or a rotating rotor eccentricity.

Defective rotor core components include, for example, the following:

1) Broken, cracked or loose rotor bars.
2) Shorted rotor laminations.

Some possible causes of a rotating rotor eccentricity are:

1) A bowed rotor.

2) Rotor not centralized in stator.

3) Increased rotor bow due to local heating in the rotor by broken rotor bars or shorted rotor laminations.

4) A rotor with high mechanical runout at its journals causing the rotor to run eccentric to the stator.

3.2.3 Rotor Bar Frequency

The rotor bar frequency (RBF) is defined as the number of rotor bars in the motor multiplied by the operating speed. Both the E3 and E4 Third Stage H_2S Blower Motors have 46 rotor bars which correspond to a RBF of approximately 2740 Hz.

Velocity spectra taken on the E3 and E4 motors' inboard bearing casing in the axial direction (Figures 23 and 24) show peaks at 1 x RBF, 2 x RBF and 3 x RBF and a series of side peaks around the 1 x RBF and its harmonics. Zoom velocity spectra (Figures 25-30) show that the frequency spacing between the peaks is approximately equal to the 2 x rpm and 1 x rpm frequencies. The appearance of several sidebands is due to significant modulation of the rotor bar frequency and its harmonics by 1 x and 2 x running speed.

These results indicate that the motor has significant rotor bar faults. It is recommended that the rotor be checked for defects such as cracked or broken rotor bars, loose rotor bars, shorted rotor laminations, etc.

4.0 ROTOR CRITICAL SPEED

The electrical problems that the motors are experiencing were previously predicted. Two studies were carried out which concluded that the motors were operating near the first rotor critical speed/1,2/. This resonant operating condition caused the rotor to vibrate at amplified levels which eventually resulted in electrically-defective rotor components (ie, cracked rotor bars, shorted laminations, etc). Electro-magnetic forces between the rotor and the stator are adversely affected causing characteristic vibration patterns such as those described in this report to appear.

5.0 CONCLUSIONS

5.1 Overall vibration levels measured on the motors' bearing casings are high and corrective action should be taken.

5.2 The main vibration frequencies are at 1 and 2 x rpm with sidebands at slip frequency and at 120 Hz.

5.3 Defective rotor/stator components and rotor eccentricity which produce unbalanced electro-magnetic forces, are the most likely causes of the high motor vibration.

5.4 High vibration at 1 x rpm is attributed to a rotor first critical speed near the operating speed amplifying the rotor response at 1 x rpm.

5.5 Continuous operation of both motors close to a rotor first critical speed is the most likely cause for the defective rotor/stator components.

6.0 RECOMMENDATIONS

6.1 The motors should be inspected for defective rotor and/or stator components and replaced if necessary.

6.2 Modifications such as motor bearing stiffening, bearing redesign and the implementation of vibration dynamic absorbers should be considered to detune the rotor critical speed.

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REFERENCES

1. Perricone, F., "Bruce Heavy Water Plant Third Stage H_2S Blower Motor Vibration Analysis," Ontario Hydro Research Division Report 81-179-K.

2. Perricone, F., "Bruce Heavy Water Plant Third Stage H_2S Blower Motor Rotor Dynamics Analysis," Ontario Hydro Research Division Report 82-505-K.

TABLE 1

'B' PLANT - E3 - THIRD STAGE H_2S BLOWER MOTOR BEARING CASING OVERALL VELOCITY LEVELS

MEASUREMENT LOCATION (SEE FIGURE 1)	VELOCITY (mm/s)	SPECTRUM FIGURE NO.
MOTOR IB HORIZONTAL	2.7 - 3.0	3
MOTOR IB VERTICAL	2.5 - 3.6	4
MOTOR IB AXIAL	3.2 - 5.4	5
MOTOR OB HORIZONTAL	2.2 - 2.7	6
MOTOR OB VERTICAL	2.3 - 3.3	7
MOTOR OB AXIAL	2.4 - 3.5	8

TABLE 2

'B' PLANT - E4 - THIRD STAGE H_2S BLOWER MOTOR BEARING CASING OVERALL VELOCITY LEVELS

MEASUREMENT LOCATION (SEE FIGURE 1)	VELOCITY (mm/s)	SPECTRUM FIGURE NO.
MOTOR IB HORIZONTAL	3.0 - 3.8	9
MOTOR IB VERTICAL	4.3 - 5.5	10
MOTOR IB AXIAL	4.3 - 9.7	11
MOTOR OB HORIZONTAL	1.5 - 2.1	12
MOTOR OB VERTICAL	2.0 - 2.9	13
MOTOR OB AXIAL	3.7 - 4.5	14

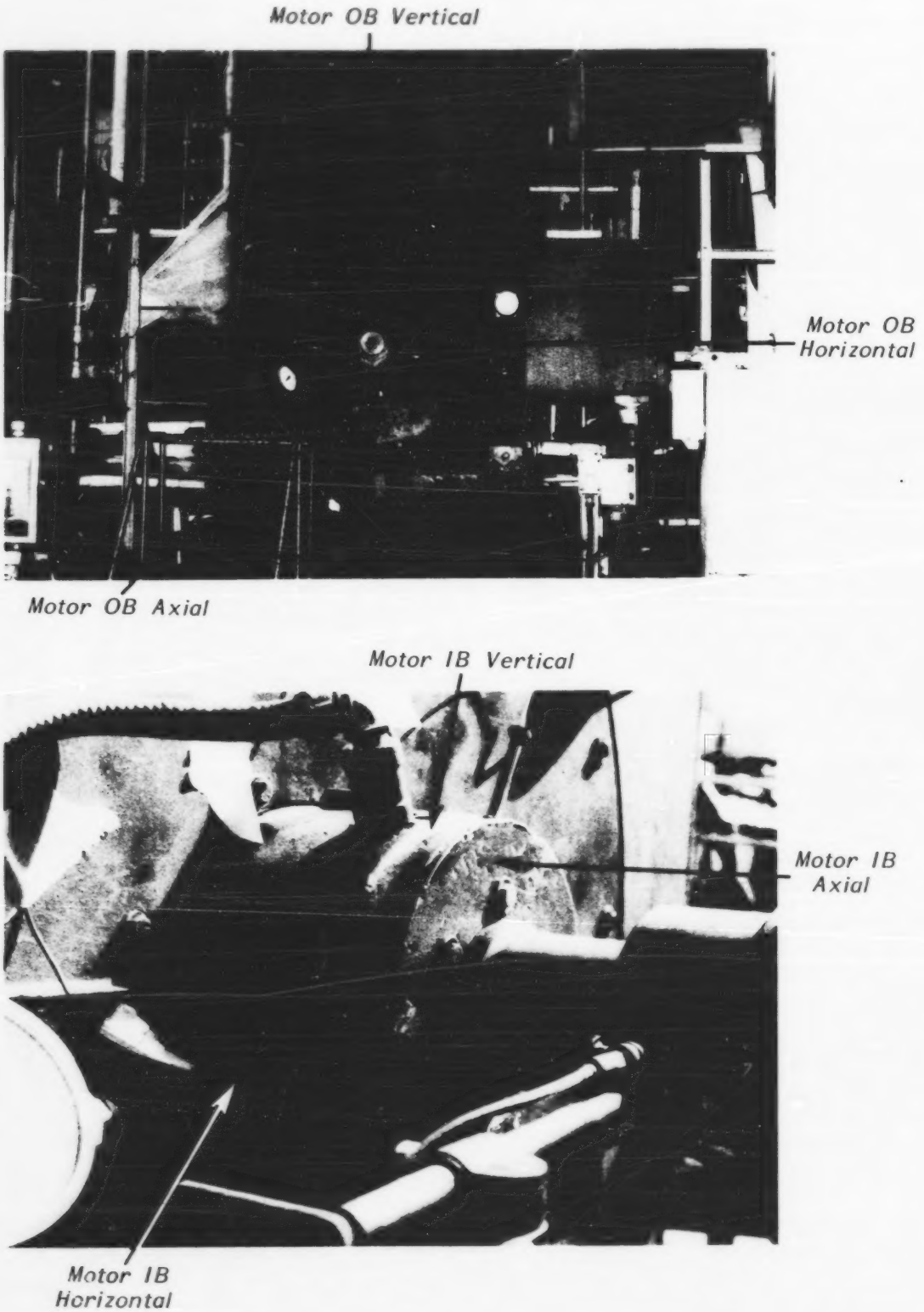
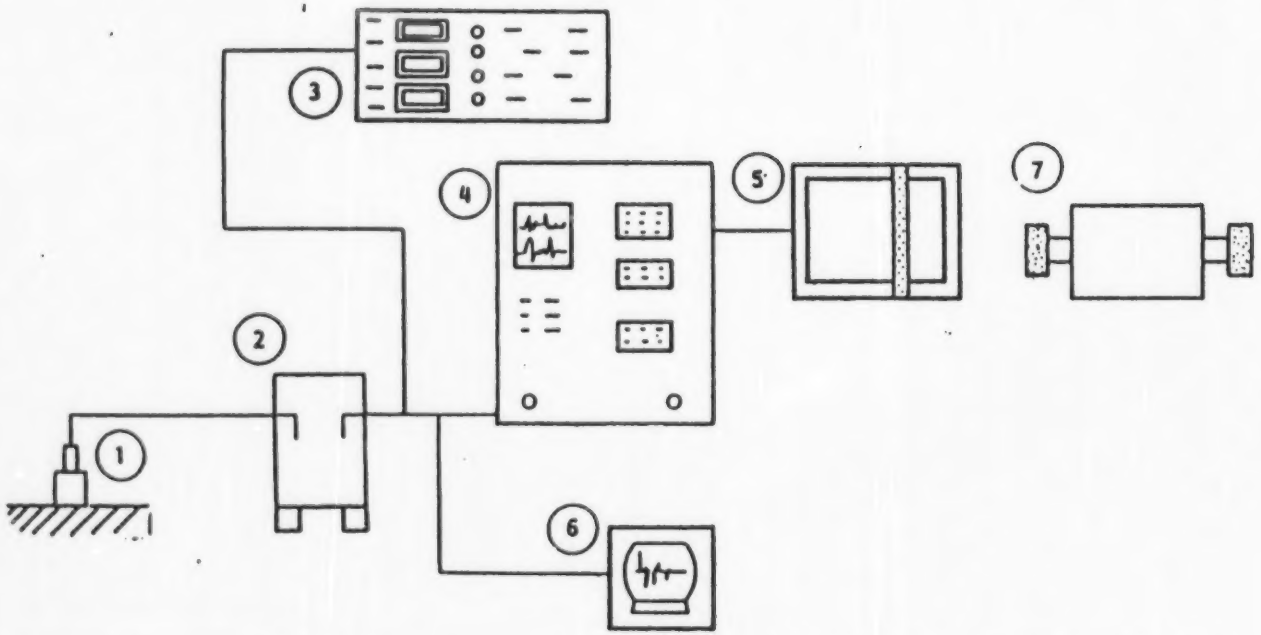


FIGURE 1

THIRD STAGE H_2S BLOWER MOTOR SHOWING VIBRATION MEASUREMENT LOCATIONS AND DIRECTIONS ON BEARING CASINGS

174013-RD



1) *Accelerometer - Bruel & Kjaer Model 4368*

2) *Charge Amplifier - Bruel & Kjaer Type 2635*

3) *Digital Vector Filter - Bently Nevada Model DVF2*

4) *FFT Analyzer - Ono Sokki Dual Channel CF 920*

5) *Plotter - Hewlett-Packward 7470 A*

6) *Oscilloscope - Textronix Model 5110 MOD 709V*

7) *Vibration Calibrator - General Radio Model 1557-A*

FIGURE 2

INSTRUMENTATION SETUP

BHWP E3- H2S BLOWER MOTOR 103- IB HORIZ VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.429E+0	EU (mm/s)
2	120.000	.126E+1	
3	480.000	.101E+0	
4			
5			
6			
7			
8			
9			
10			

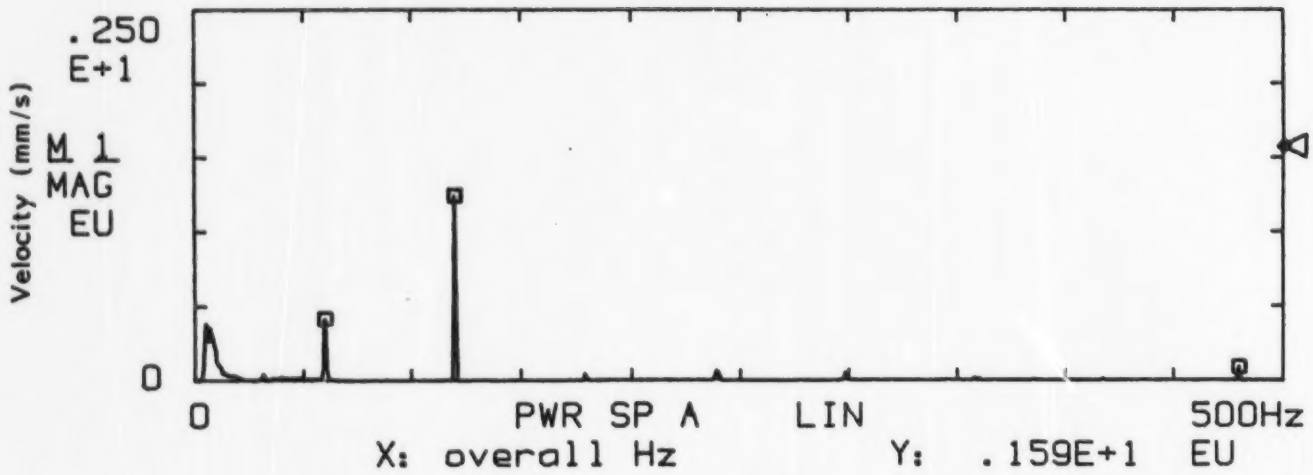


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FIGURE 3
E3 - MOTOR INBOARD BEARING CASING VELOCITY HORIZONTAL DIRECTION

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BHWP E3- H2S BLOWER MOTOR 103- IB VERT VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.261E+0	EU (mm/s)
2	120.000	.135E+1	
3			
4			
5			
6			
7			
8			
9			
10			

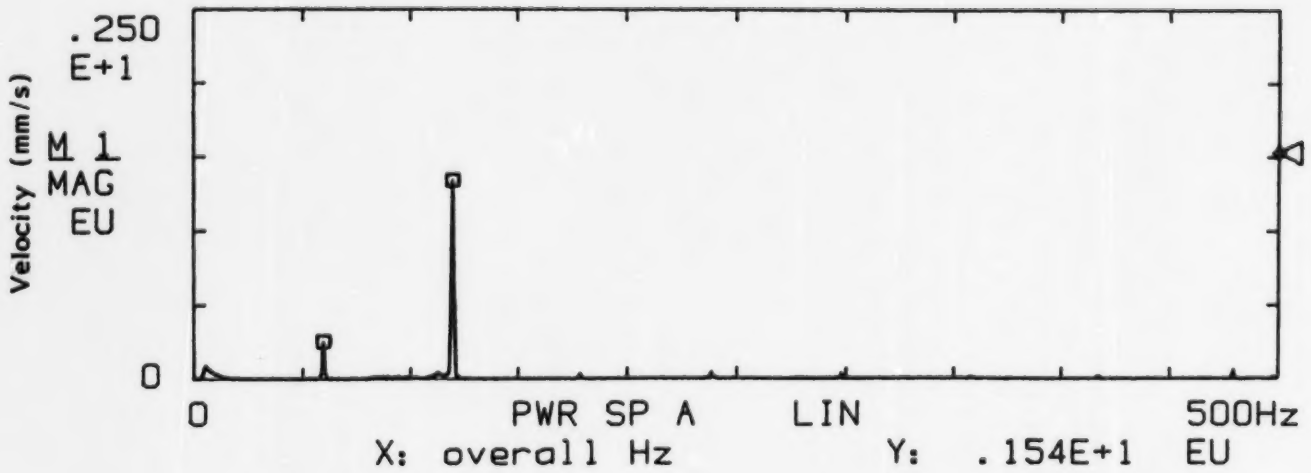

FIGURE 4
E3 - MOTOR INBOARD BEARING CASING VELOCITY VERTICAL DIRECTION

01:19

BHWP E3- H2S BLOWER MOTOR 103- IB AXIAL VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.518E+0	EU (mm/s)
2	120.000	.271E+1	
3			
4			
5			
6			
7			
8			
9			
10			

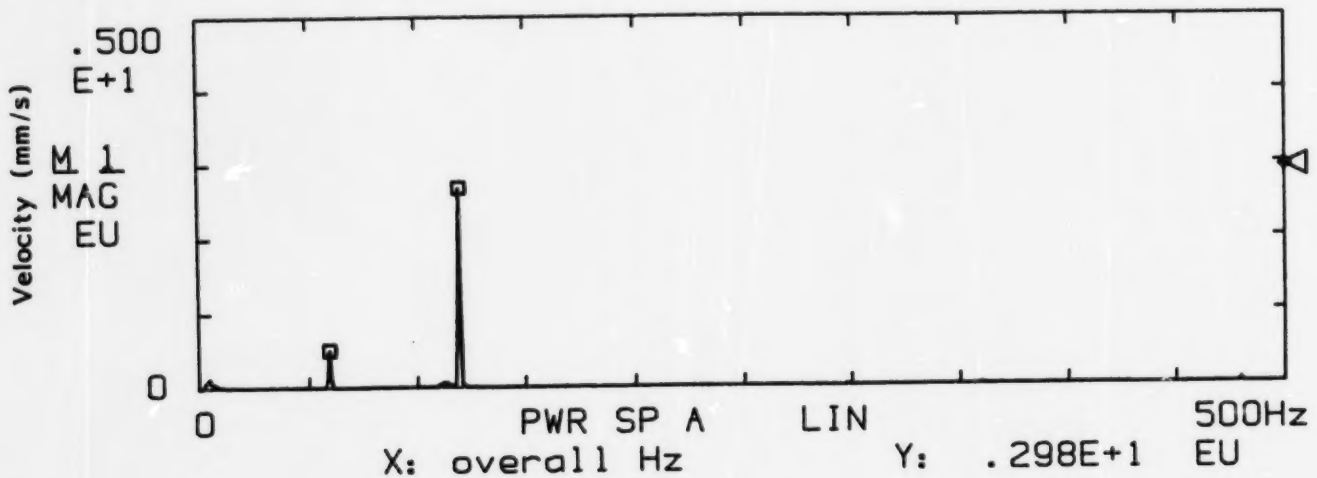

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FIGURE 5

E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION

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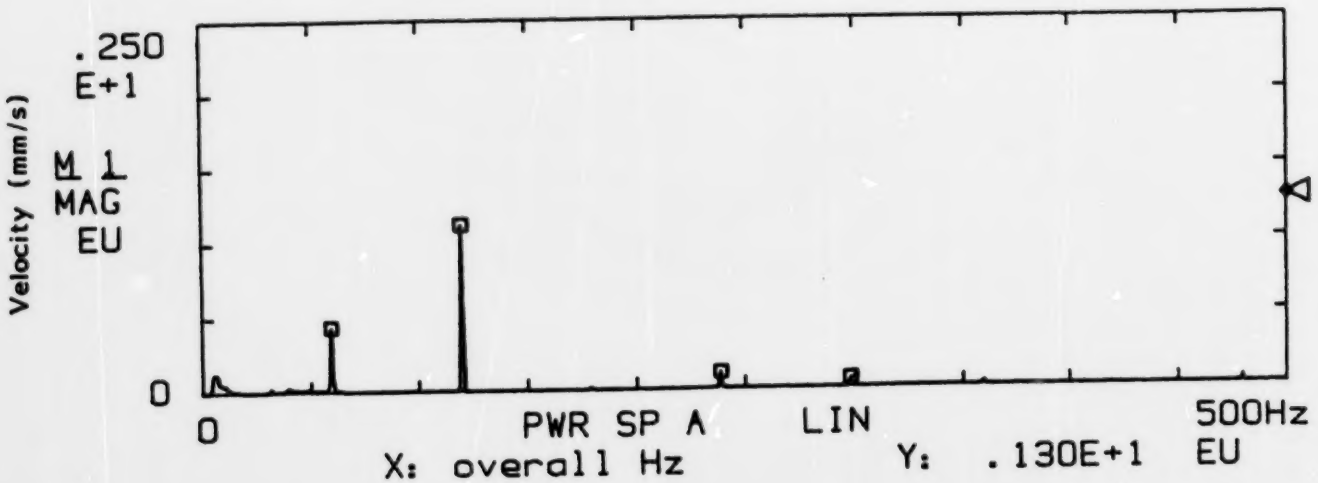
BHWP E3- H2S BLOWER MOTOR 103- OB HORIZ VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.451E+0	EU (mm/s)
2	120.000	.114E+1	
3	238.750	.117E+0	
4	298.125	.675E-1	
5			
6			
7			
8			
9			
10			



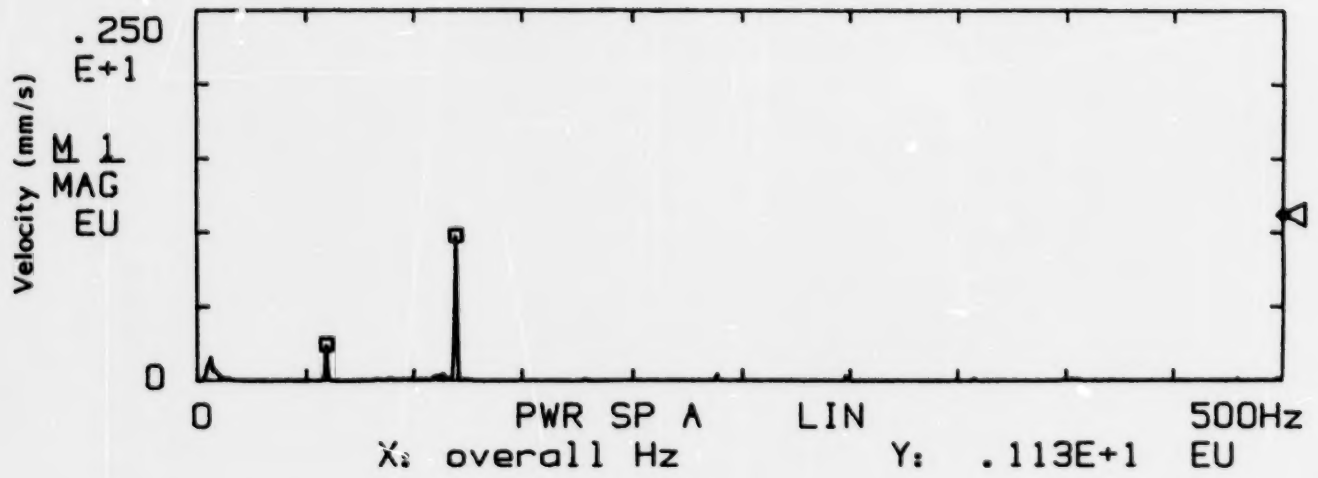
03: 27

FIGURE 6

E3 - MOTOR OUTBOARD BEARING CASING VELOCITY HORIZONTAL DIRECTION

BHWP E3- H2S BLOWER MOTOR 103- OB VERT VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.252E+0	EU (mm/s)
2	120.000	.990E+J	
3			
4			
5			
6			
7			
8			
9			
10			



03:59

FIGURE 7

E3 - MOTOR OUTBOARD BEARING CASING VELOCITY VERTICAL DIRECTION

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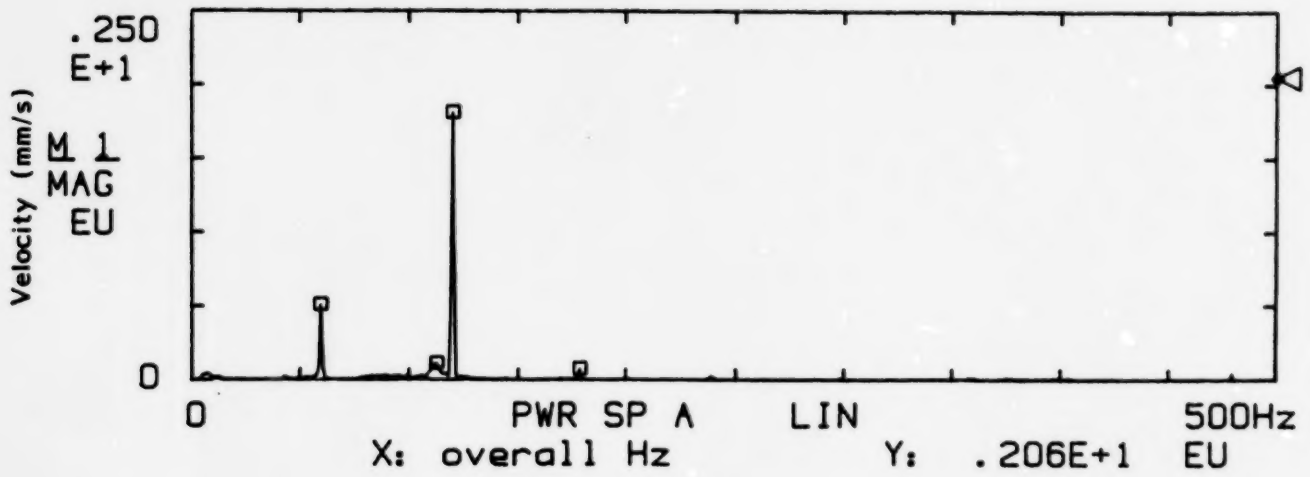
BHWP E3- H2S BLOWER MOTOR 103- OB AXIAL VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.517E+0	EU (mm/s)
2	112.500	.118E+0	
3	120.000	.182E+1	
4	178.750	.849E-1	
5			
6			
7			
8			
9			
10			



04: 20

FIGURE 8

E3 - MOTOR OUTBOARD BEARING CASING VELOCITY AXIAL DIRECTION

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BHWP E4- H2S BLOWER MOTOR 103- IB HORIZ VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.946E+0	EU (mm/s)
2	120.000	.639E+0	
3	178.750	.154E+0	
4	239.375	.494E-1	
5	298.125	.824E-1	
6			
7			
8			
9			
10			

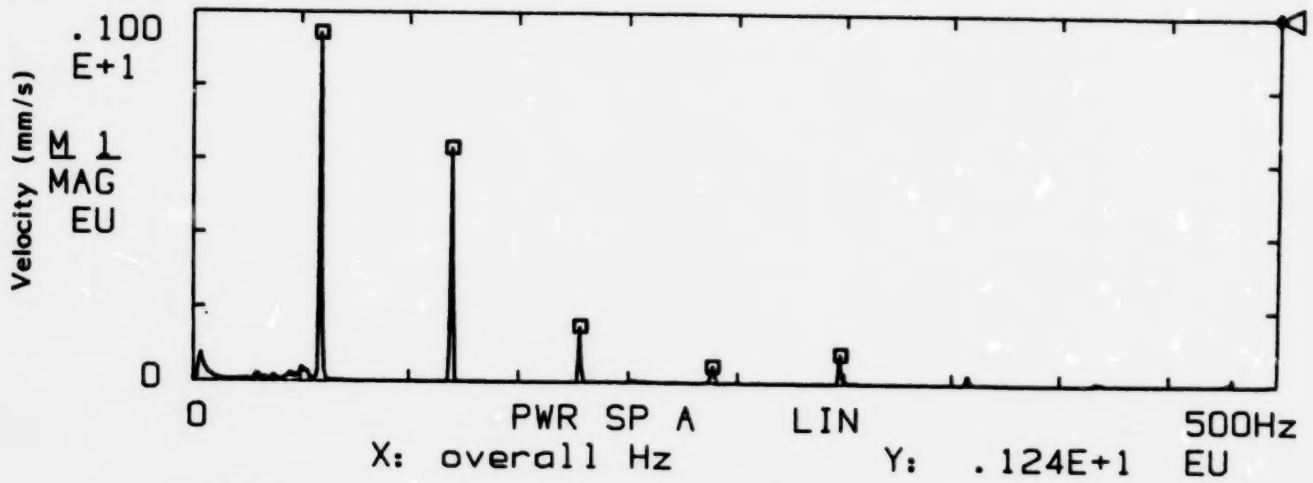

FIGURE 9

E4 - MOTOR INBOARD BEARING CASING VELOCITY HORIZONTAL DIRECTION

01:12

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BHWP E4- H2S BLOWER MOTOR 103- IB VERT VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.792E+0	EU (mm/s)
2	120.000	.273E+1	
3			
4			
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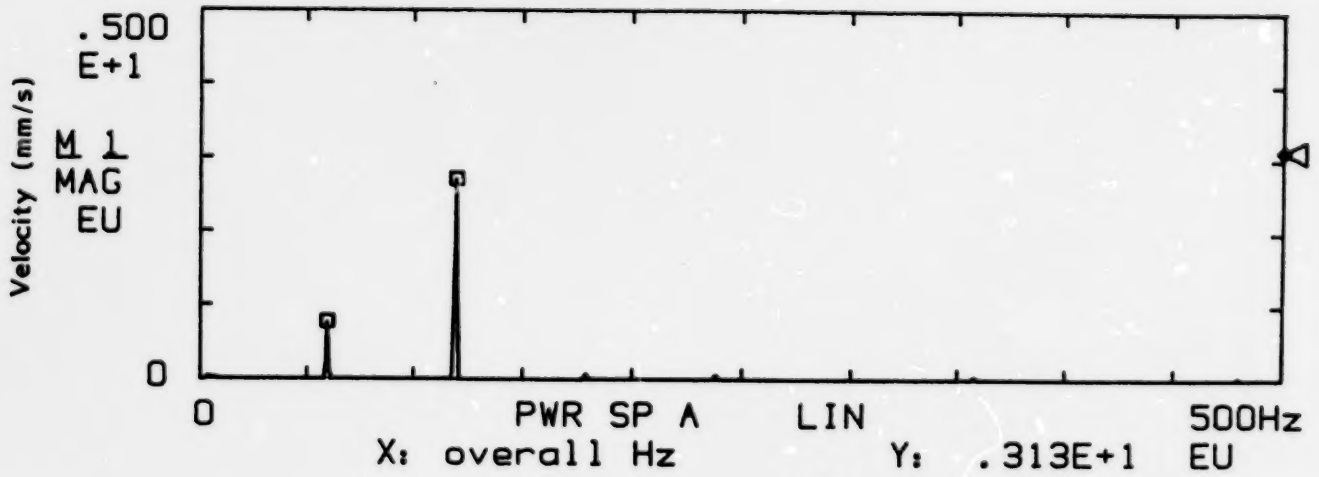
7			
8			
9			
10			

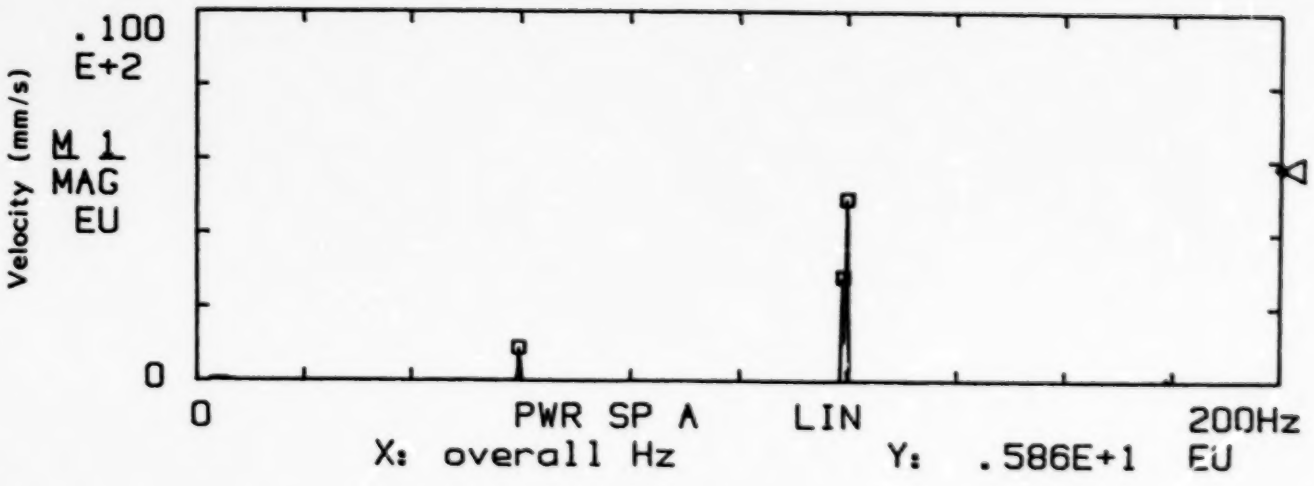


01:52

FIGURE 10
E4 - MOTOR INBOARD BEARING CASING VELOCITY VERTICAL DIRECTION

BHWP E4- H2S BLOWER MOTOR IB AXIAL VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.500Hz	.934E+0	EU (mm/s)
2	119.250	.285E+1	
3	120.000	.494E+1	
4			
5			
6			
7			
8			
9			
10			



00: 38

FIGURE 11
E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION

BHWP E4- H2S BLOWER MOTOR OB HORIZ VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.500Hz	.798E+0	EU (mm/s)
2	119.250	.180E+0	
3	120.000	.679E+0	
4	178.750	.393E-1	
5			
6			
7			
8			
9			
10			

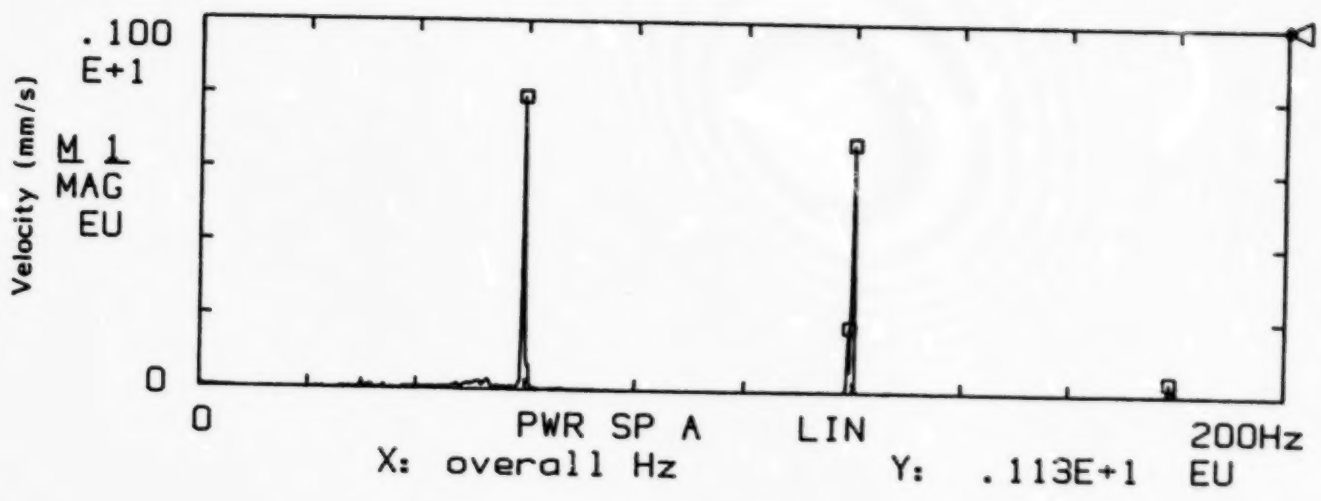


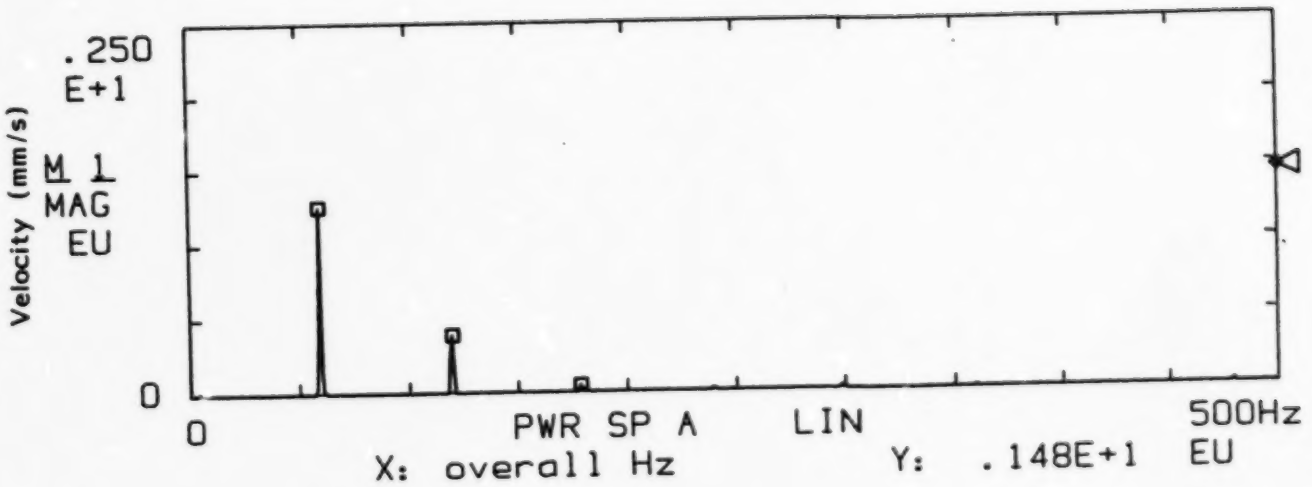
FIGURE 12

E4 - MOTOR OUTBOARD BEARING CASING VELOCITY HORIZONTAL DIRECTION

00: 28

BHWP E4- H2S BLOWER MOTOR 103- OB VERT VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.375Hz	.128E+1	EU (mm/s)
2	120.000	.404E+0	
3	178.750	.500E-1	
4			
5			
6			
7			
8			
9			
10			



00: 34

FIGURE 13

E4 - MOTOR OUTBOARD BEARING CASING VELOCITY VERTICAL DIRECTION

BHWP E4- H2S BLOWER MOTOR OB AXIAL VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA	
1	59.500Hz	.174E+1	EU (mm/s)
2	119.250	.725E+0	
3	120.000	.154E+1	
4	178.750	.834E-1	
5			
6			
7			
8			
9			
10			

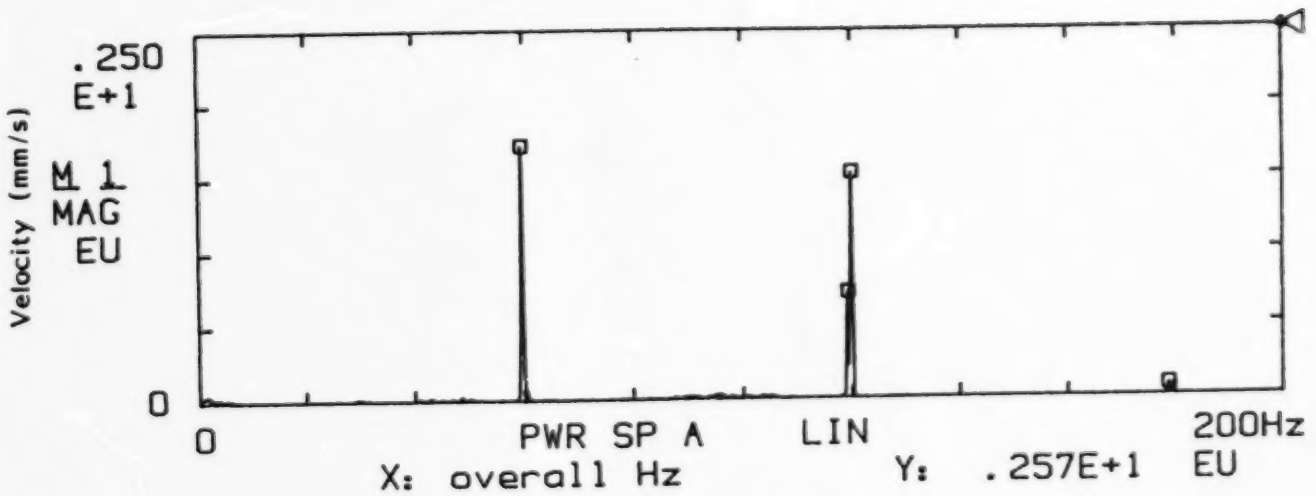


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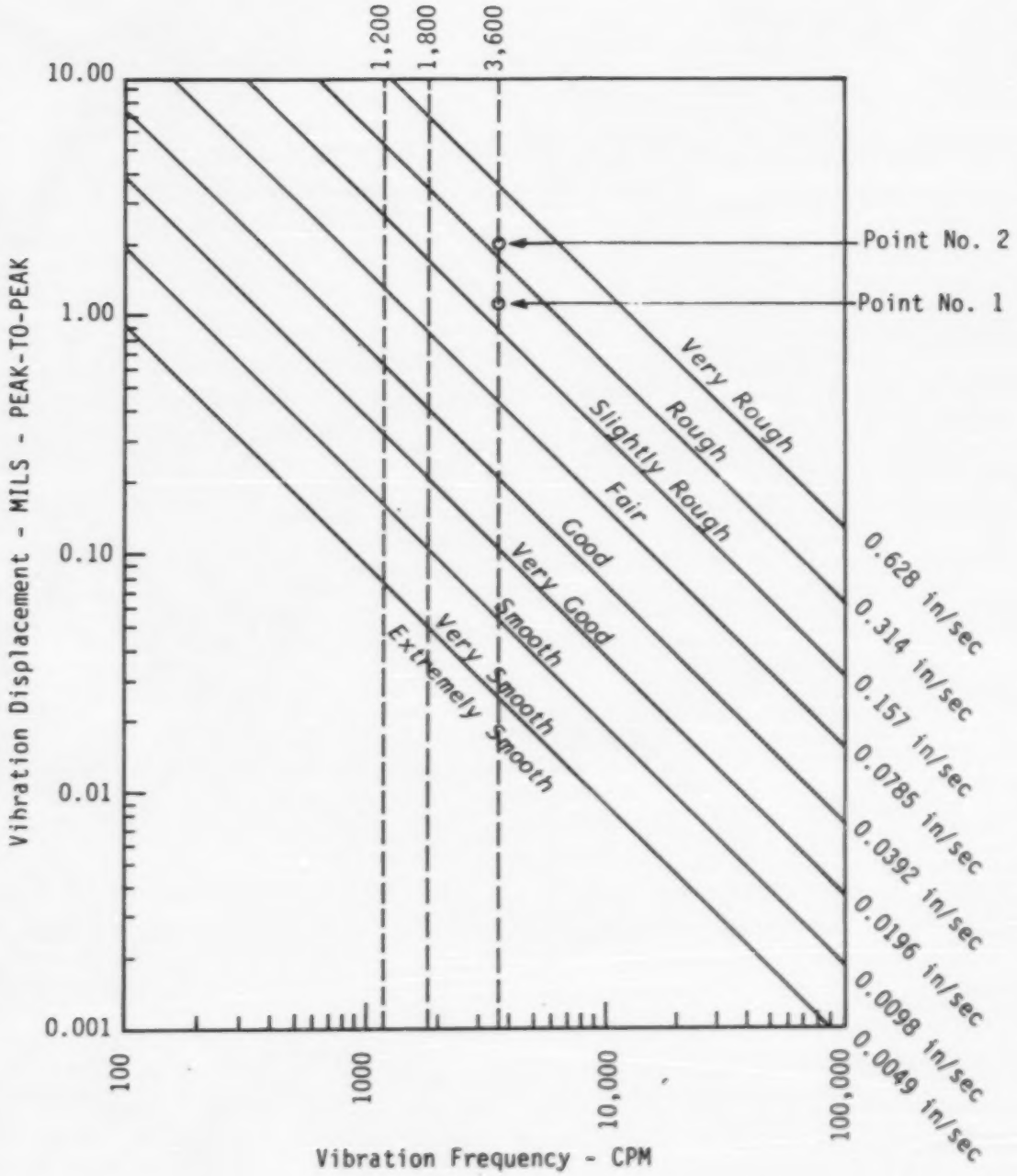
FIGURE 14
E4 - MOTOR OUTBOARD BEARING CASING VELOCITY AXIAL DIRECTION



Point No.1: Maximum Velocity Level Measured on E3 Blower Motor
Point No.2: Maximum Velocity Level Measured on E4 Blower Motor

FIGURE 15

MOTOR VIBRATION LEVELS PLOTTED ON A GENERAL MACHINERY VIBRATION SEVERITY CHART

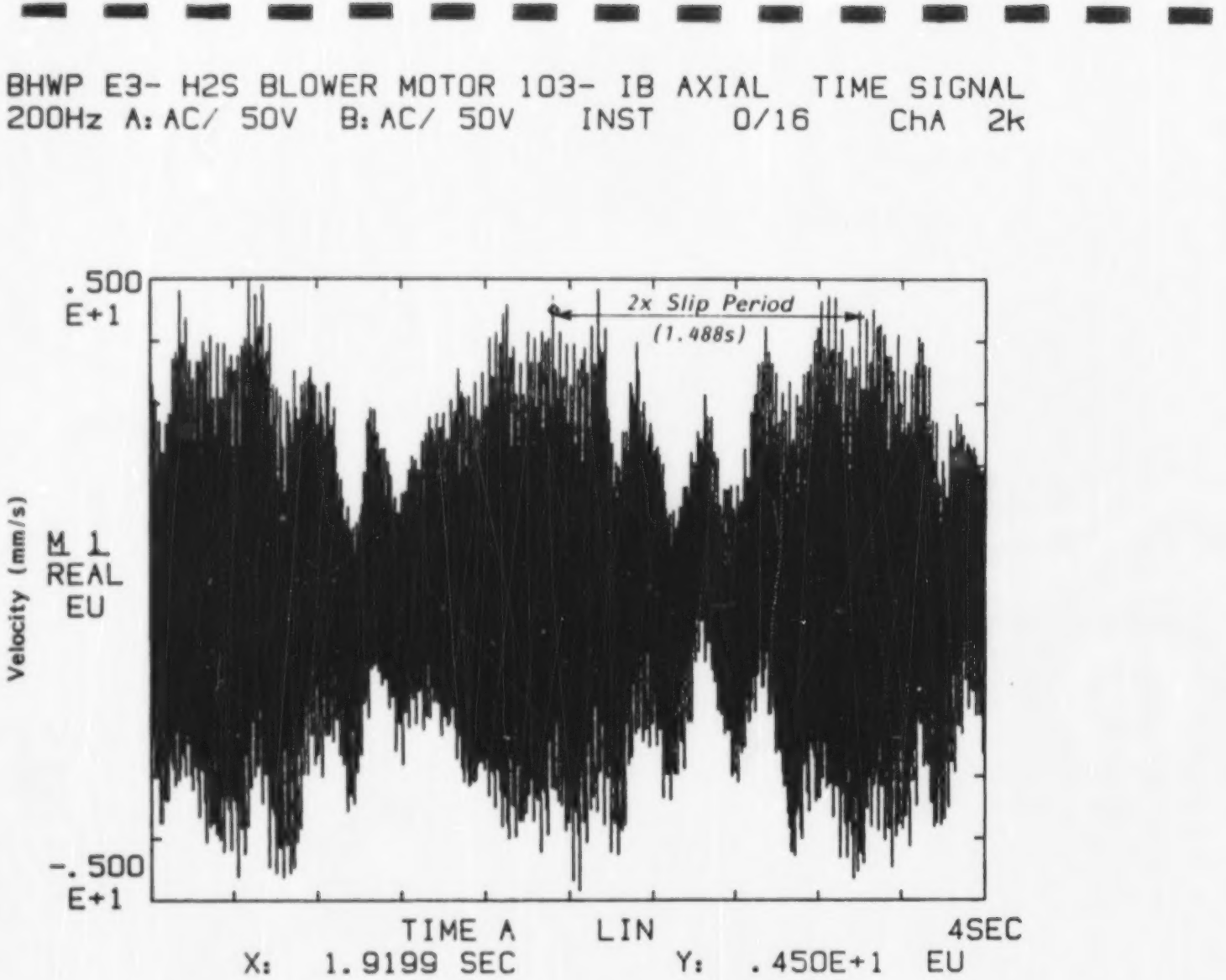


FIGURE 16

E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - TIME SIGNAL

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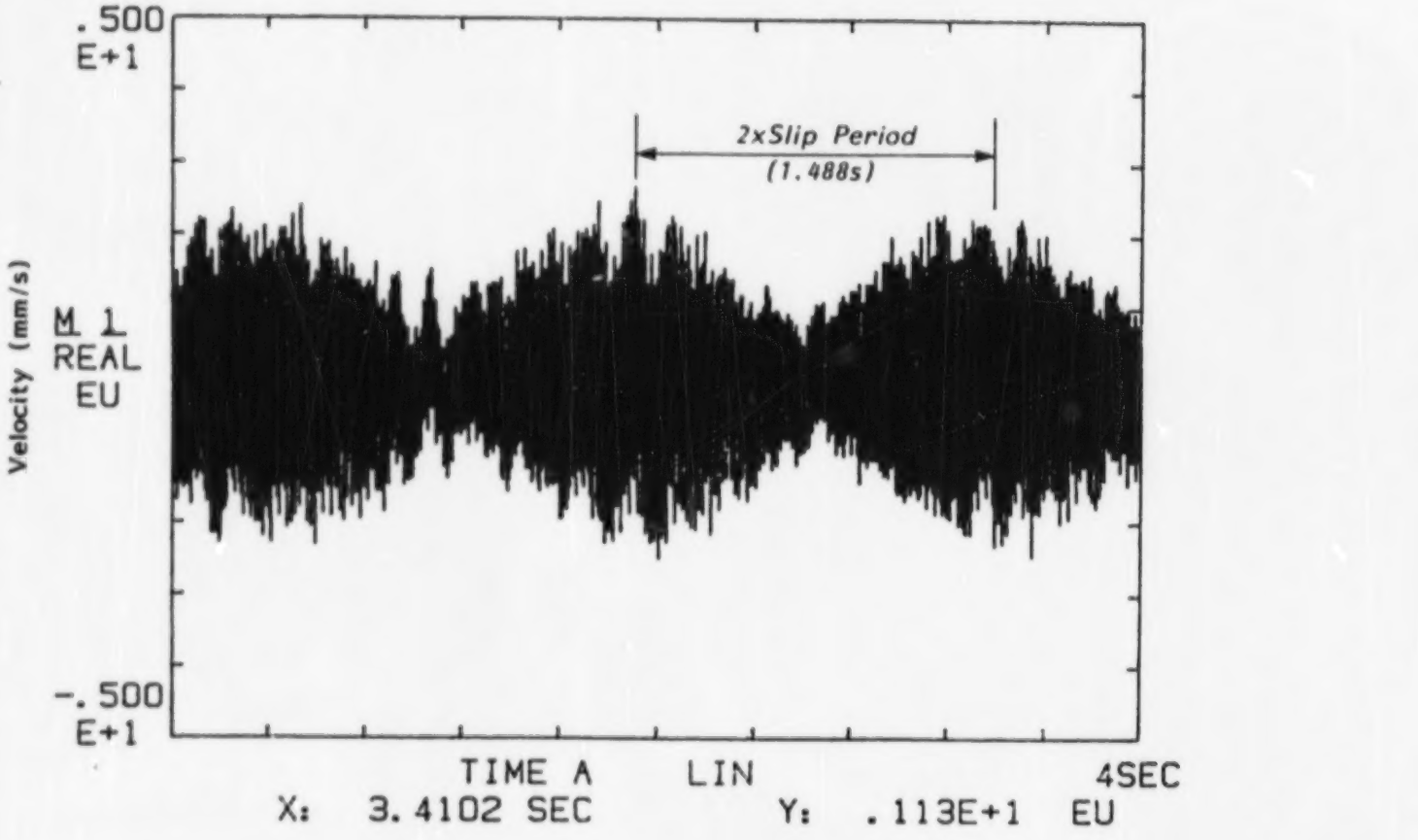
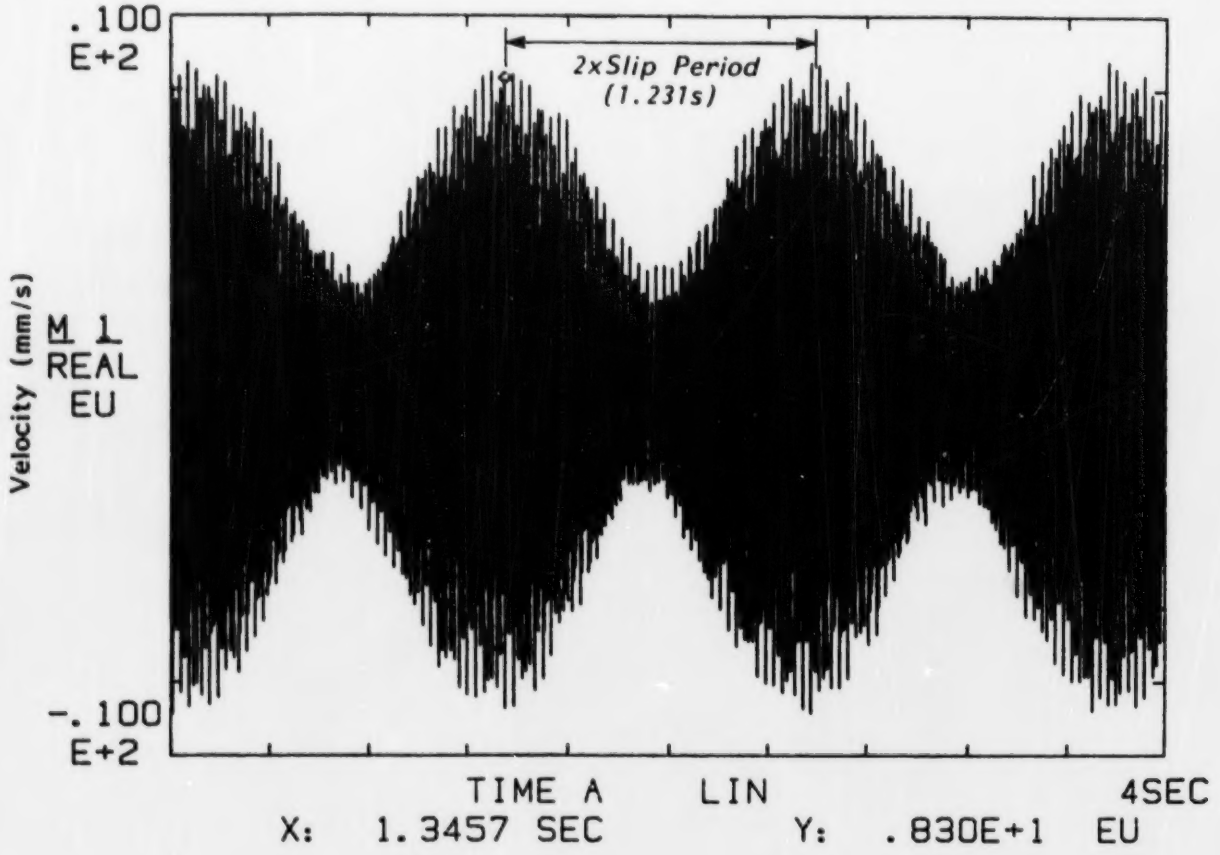


FIGURE 17

E3 - MOTOR INBOARD BEARING CASING VELOCITY VERTICAL DIRECTION - TIME SIGNAL

BHWP E4- H2S BLOWER MOTOR 103- IB AXIAL TIME SIGNAL
200Hz A: AC/ 50V B: AC/ 50V INST 0/16 ChA 2k



00: 13

FIGURE 18

E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - TIME SIGNAL

BHWP E3- H2S BLOWER MOTOR 103- IB AXIAL ZOOM VEL SPEC
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	59.0000Hz	-41.2dBEU*
2	59.6719 (1xRPM)	-4.5 (0.60mm/s)
3	60.3437	-35.0
4	61.0156	-42.3
5		
6		
7		
8		
9		
10		

EU=mm/s

* Reference Velocity is 1mm/s

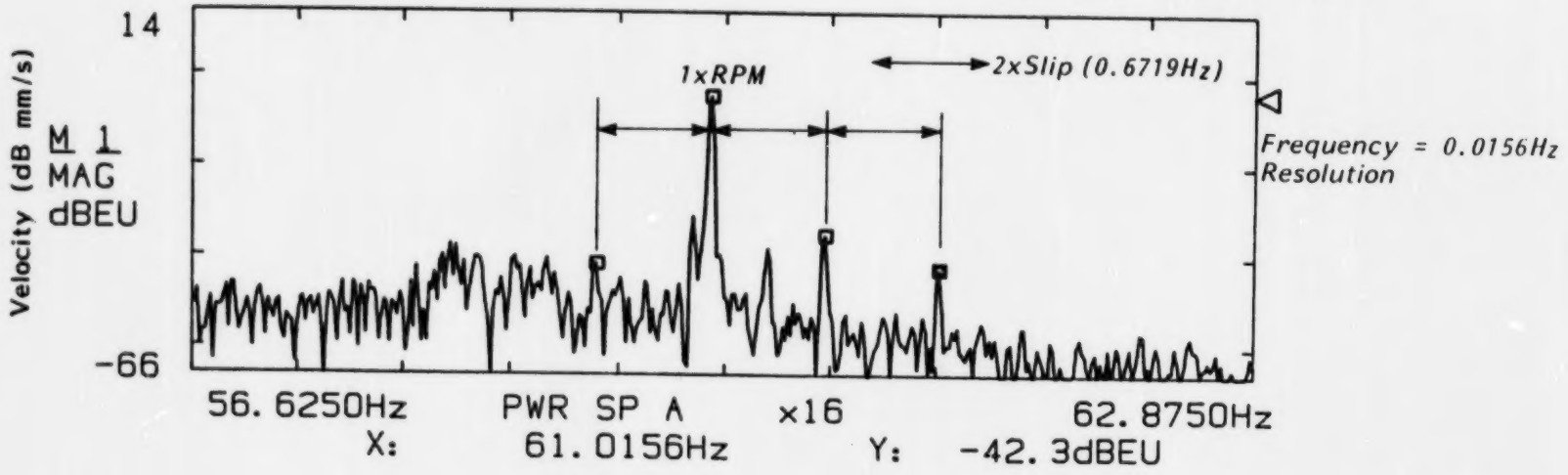


FIGURE 19

E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

00: 03

BHWP E3- H2S BLOWER MOTOR 103- IB AXIAL ZOOM VEL SPEC
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

PWR SPECTRUM ChA

1	119.3359Hz (2xRPM)	1.0dBEU*	(1.12mm/s)
2	120.0078	8.4	(2.63mm/s)
3	120.6797	-33.1	
4			
5			
6			
7			
8			
9			
10			

EU=mm/s
* Reference Velocity is 1mm/s

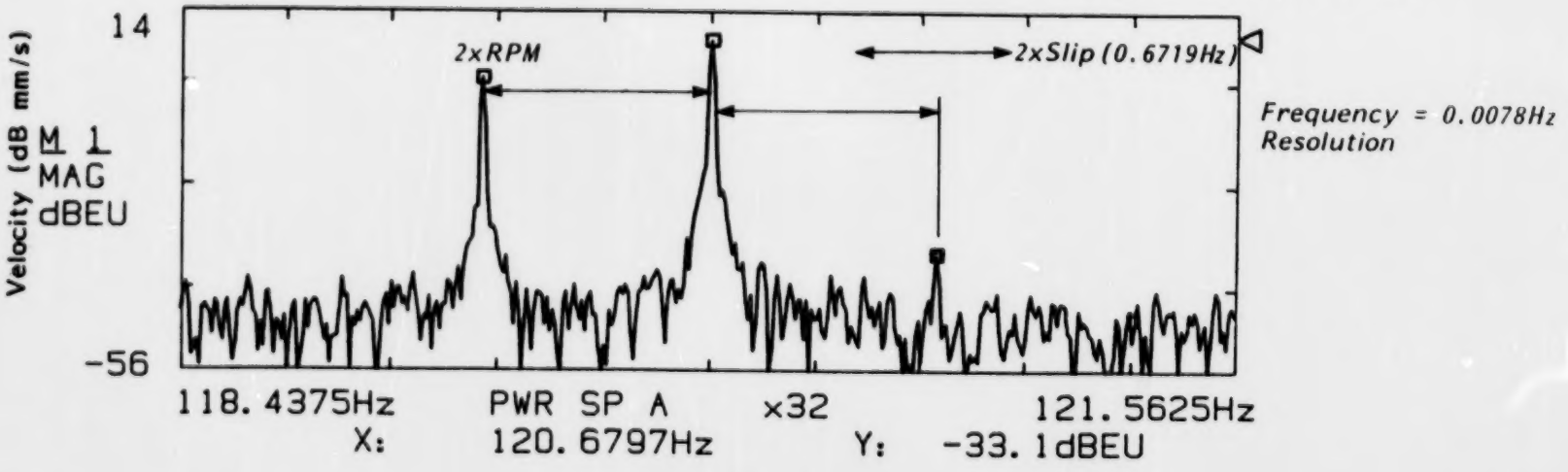


FIGURE 20

00: 41

E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E4- H2S BLOWER MOTOR 103-IB AXIAL ZOOM VEL SPEC
200Hz A: AC/0.5V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM ChA		
1	58.7812Hz	-40.6dBEU*	
2	59.5937 (1xRPM)	.5	(1.06mm/s)
3	60.4062	-35.3	
4			
5			
6			
7			
8			
9			
10			

EU=mm/s

**Reference Velocity is 1mm/s*

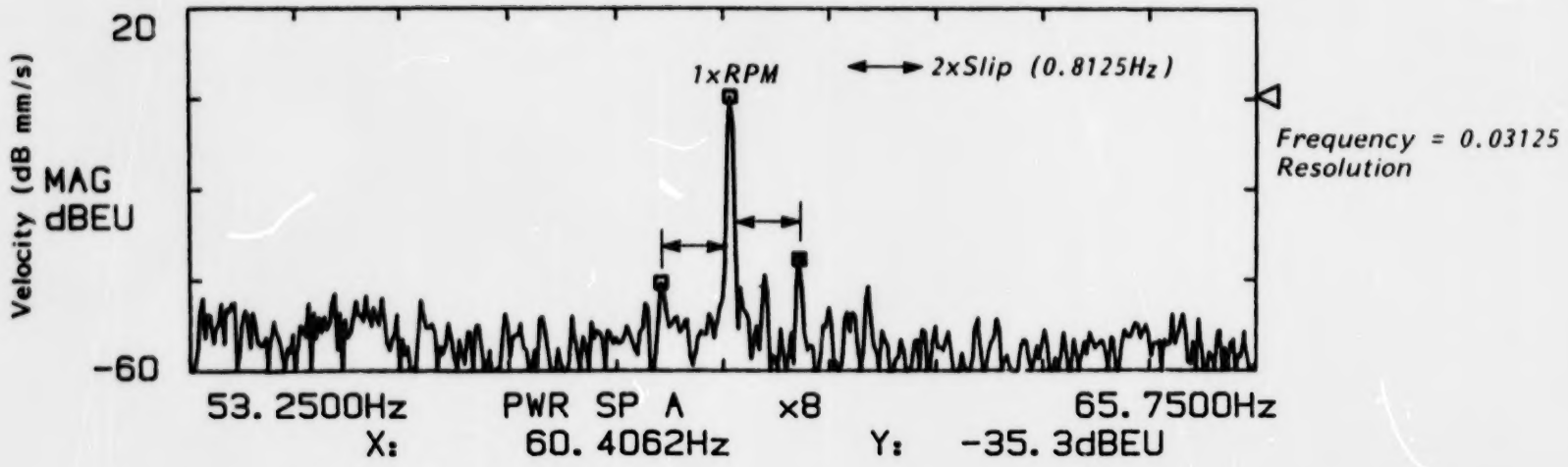


FIGURE 21

00: 05

E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E4- H2S BLOWER MOTOR 103-IB AXIAL ZOOM VEL SPEC
200Hz A: AC/0.5V B: AC/ 50V S.SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	118.3750Hz	-26.6dBEU*
2	119.1875 (2xRPM)	9.2 (2.88mm/s)
3	120.0000	13.9 (4.95mm/s)
4		
5		
6		
7		
8		
9		
10		

EU=mm/s
*Reference Velocity is 1mm/s

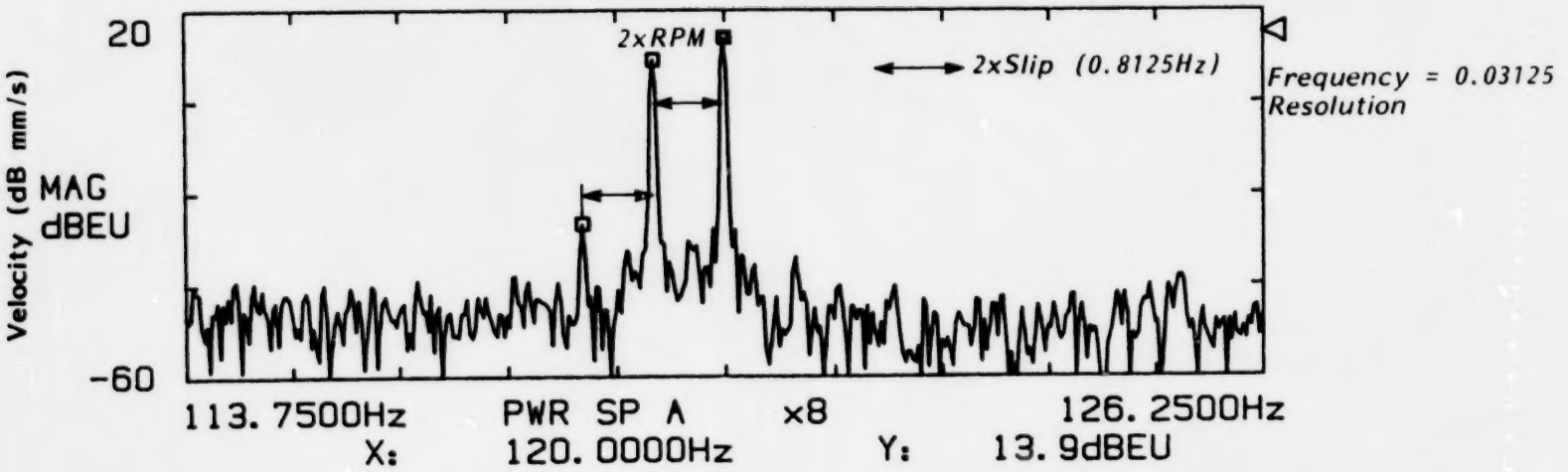


FIGURE 22

00: 14

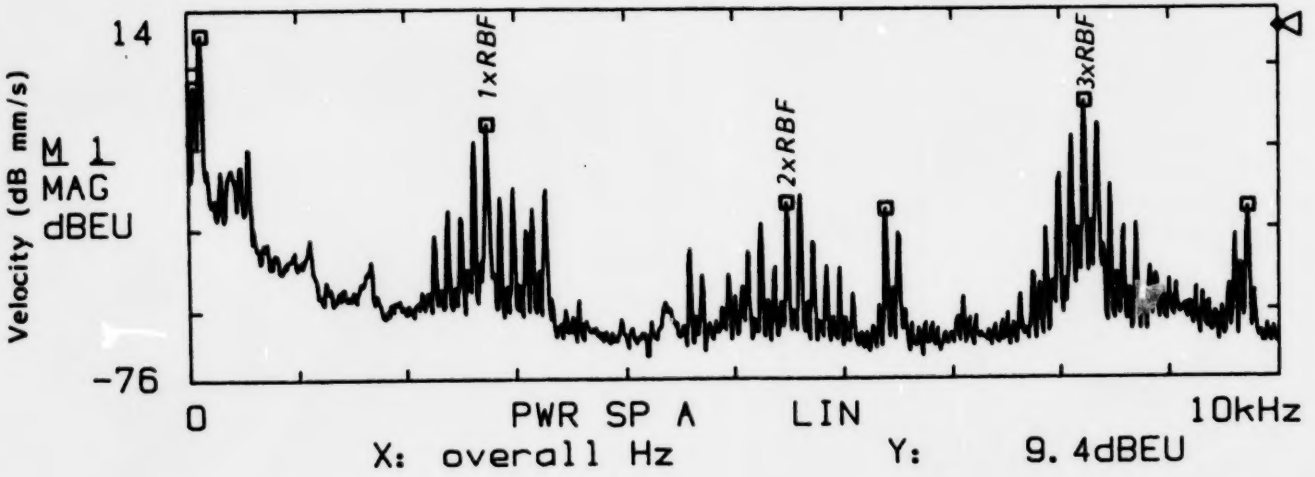
E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E3- H2S BLOWER MOTOR 103- IB AXIAL VEL SPECTRUM
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM		ChA
1	62.5Hz		-4.6dBEU* (0.59mm/s)
2	125.0		8.1
3	2750.0	(1xRBF)	-13.9
4	5487.5	(2xRBF)	-33.3
5	6387.5		-34.6
6	8237.5	(3xRBF)	-8.5
7	9725.0		-34.4
8			
9			
10			

EU=mm/s

* *Reference Velocity is 1mm/s*



00: 32

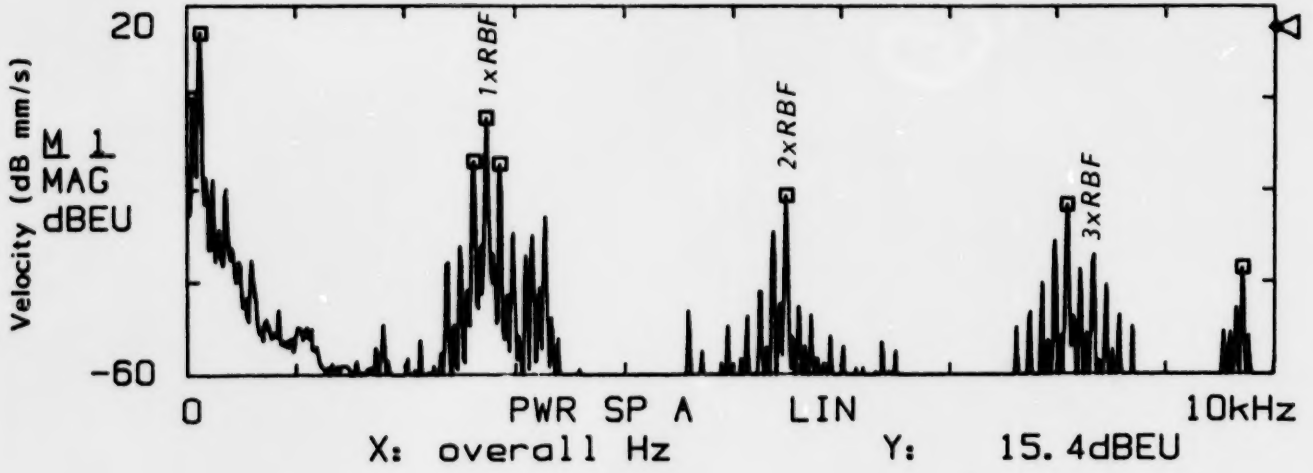
FIGURE 23

E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION

BHWP E4- H2S BLOWER MOTOR 103- IB AXIAL VEL SPECTRUM
10kHz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	62.5Hz	.1dBEU* (1.01mm/s)
2	125.0	14.1
3	2625.0	-13.5
4	2737.5 (1xRBF)	-4.1
5	2862.5	-14.0
6	5487.5 (2xRBF)	-21.1
7	8100.0	-22.9
8	9712.5	-36.8
9		
10		

EU=mm/s
* Reference Velocity is 1mm/s



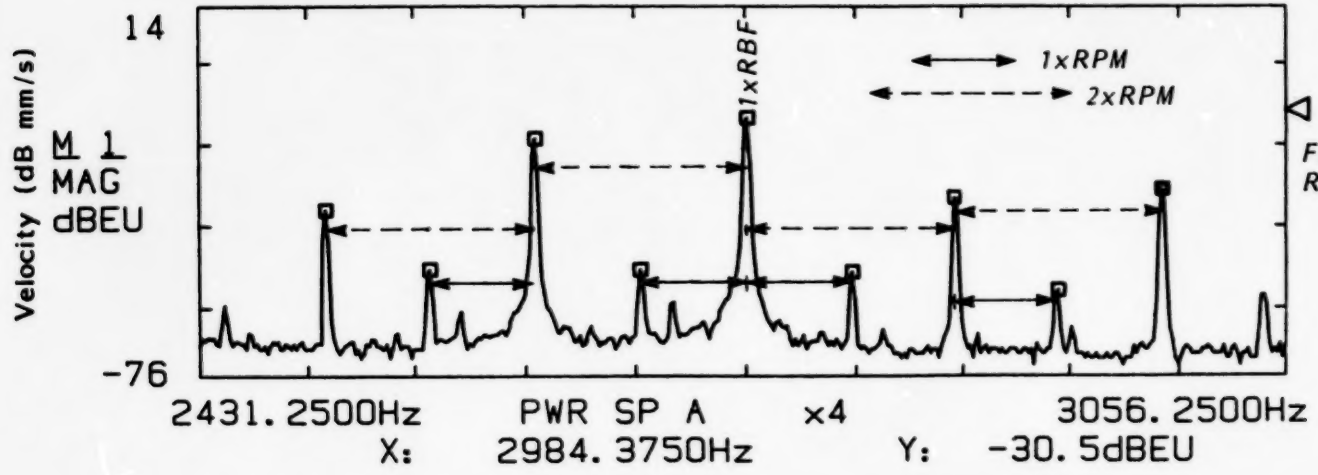
02:24

FIGURE 24
E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION

BHWP E3- H2S BLOWER MOTOR 103- IB AXIAL ZOOM VEL SPEC
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	2504.6875Hz	-35.7dBEU *
2	2565.6250	-50.0
3	2625.0000	-18.0
4	2684.3750	-50.0
5	2745.3125	-13.0 (0.22mm/s)
6	2804.6875	-50.3
7	2864.0625	-32.5
8	2925.0000	-54.9
9	2984.3750	-30.5
10		

EU=mm/s
** Reference Velocity is 1mm/s*



00:08

FIGURE 25

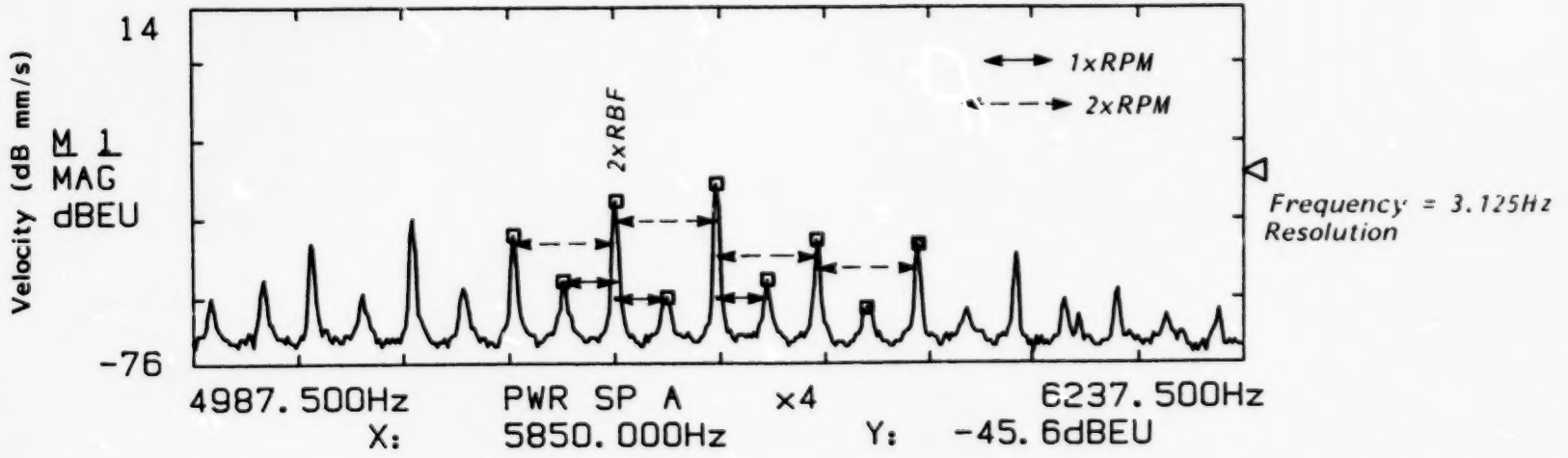
E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E3- H2S BLOWER MOTOR 103- IB AXIAL ZOOM VEL SPEC
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	5368.750Hz	-43.5dBEU *
2	5428.125	-54.9
3	5490.625	-34.7 (0.02mm/s)
4	5550.000	-59.1
5	5609.375	-30.5
6	5668.750	-54.6
7	5728.125	-44.6
8	5787.500	-61.6
9	5850.000	-45.6
10		

EU=mm/s

* *Reference Velocity is 1mm/s*



00: 12

FIGURE 26

E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E3- H2S BLOWER MOTOR 103- IB AXIAL ZOOM VEL SPEC
200Hz A: AC/ 50V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	7993.750Hz	-25.8dBEU *
2	8053.125	-52.4
3	8112.500	-19.1
4	8175.000	-41.5
5	8234.375	-8.9 (0.36mm/s)
6	8293.750	-38.8
7	8353.125	-13.9
8	8412.500	-44.7
9	8475.000	-30.8
10	8593.750	-39.1

EU=mm/s
** Reference Velocity is 1mm/s*

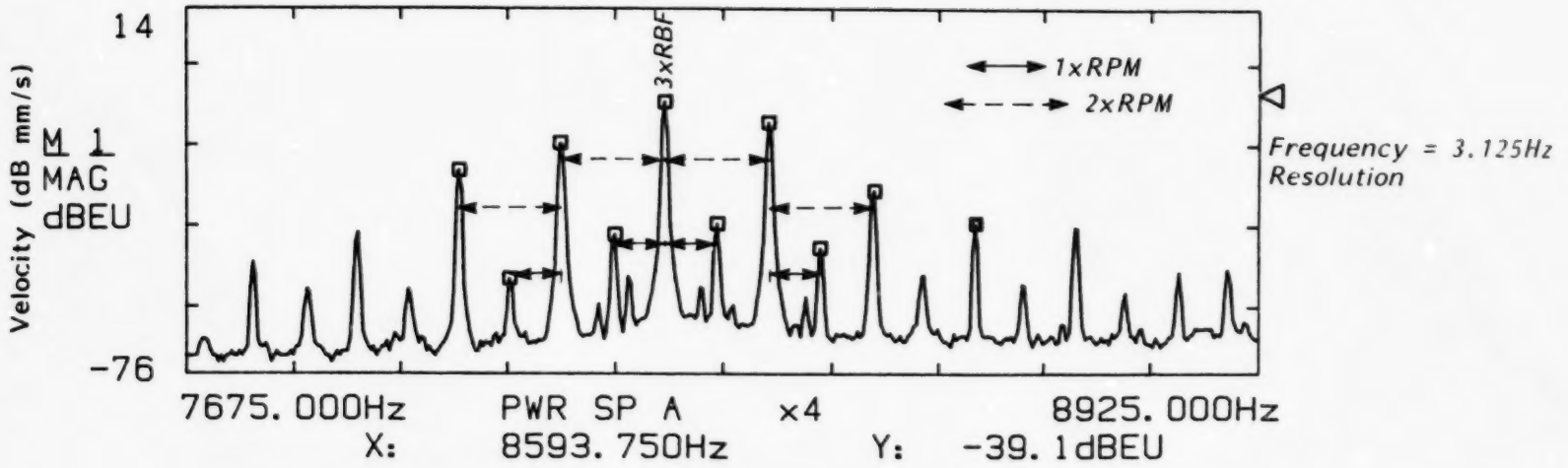


FIGURE 27

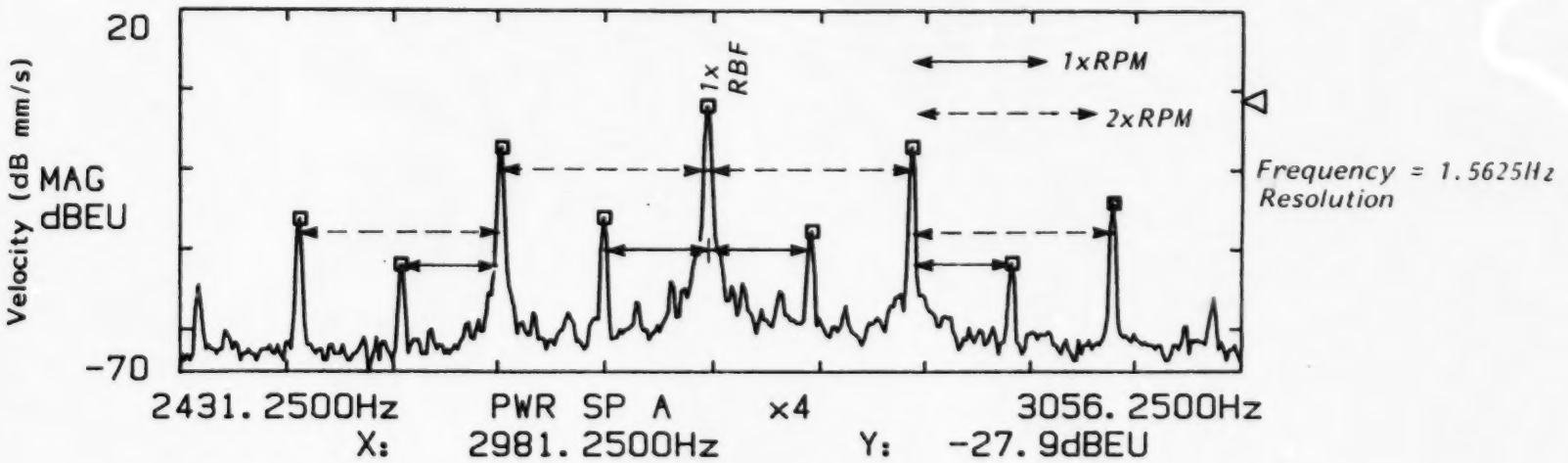
00:22

E3 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E4- H2S BLOWER MOTOR 103-IB AXIAL ZOOM VEL SPEC
5kHz A: AC/0.5V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	2501.5625Hz	-32.0dBEU *
2	2560.9375	-43.2
3	2621.8750	-14.2
4	2681.2500	-31.5
5	2740.6250	-3.7 (0.65mm/s)
6	2801.5625	-34.9
7	2860.9375	-13.9
8	2920.3125	-42.7
9	2981.2500	-27.9
10		

EU=mm/s
** Reference Velocity is 1mm/s*



00:30

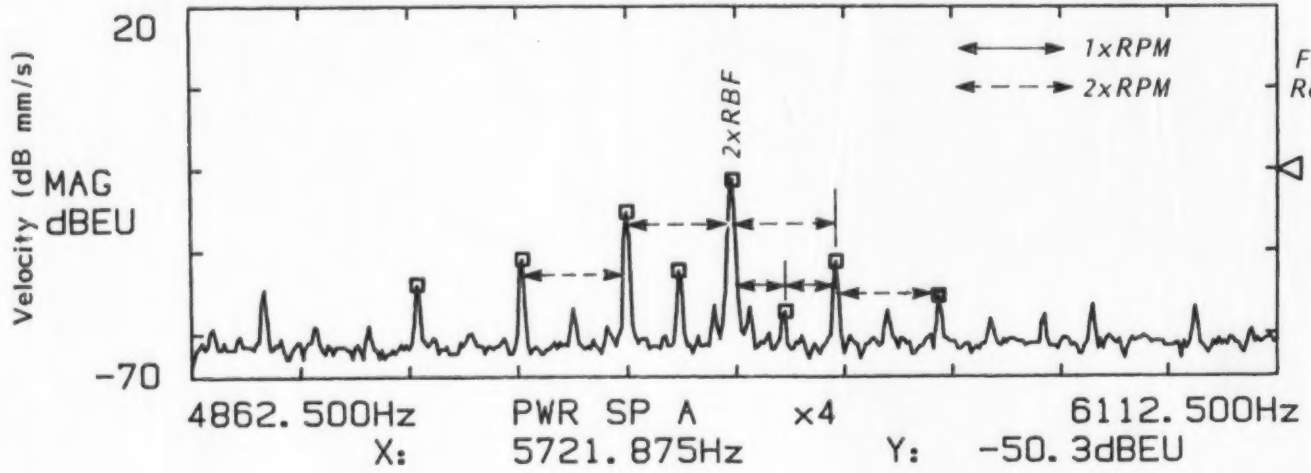
FIGURE 28

E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E4- H2S BLOWER MOTOR 103-IB AXIAL ZOOM VEL SPEC
10kHz A: AC/0.5V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	5121.875Hz	-47.6dBEU *
2	5243.750	-41.2
3	5362.500	-29.8
4	5421.875	-44.1
5	5484.375	-22.3 (0.08mm/s)
6	5543.750	-54.1
7	5603.125	-42.1
8	5721.875	-50.3
9		
10		

EU=mm/s
** Reference Velocity is 1mm/s*



00: 53

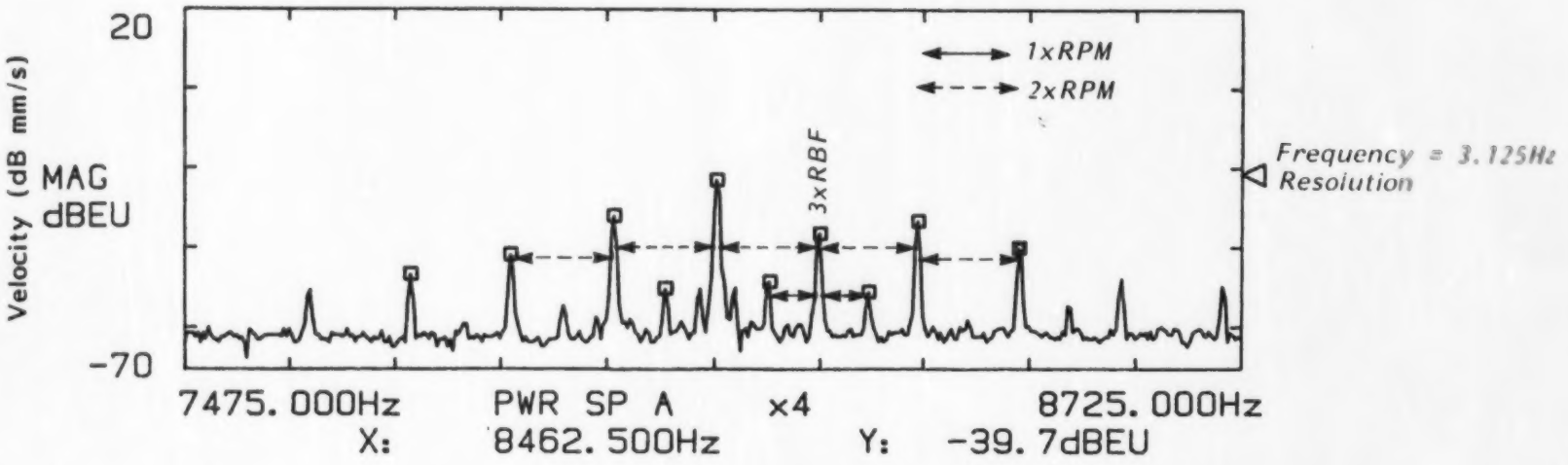
FIGURE 29

E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

BHWP E4- H2S BLOWER MOTOR 103-IB AXIAL ZOOM VEL SPEC
10kHz A: AC/0.5V B: AC/ 50V S. SUM 16/16 ChA 2k

	PWR SPECTRUM	ChA
1	7743.750Hz	-46.0dBEU*
2	7862.500	-41.5
3	7984.375	-31.5
4	8043.750	-49.8
5	8103.125	-22.7
6	8165.625	-48.1
7	8225.000	-36.0 (0.016mm/s)
8	8284.375	-50.6
9	8343.750	-32.9
10	8462.500	-39.7

EU=mm/s
* Reference Velocity is 1mm/s



00: 44

FIGURE 30

E4 - MOTOR INBOARD BEARING CASING VELOCITY AXIAL DIRECTION - ZOOM SPECTRUM

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